Operational Experience of Lithium Polymer Batteries for Small Satellites

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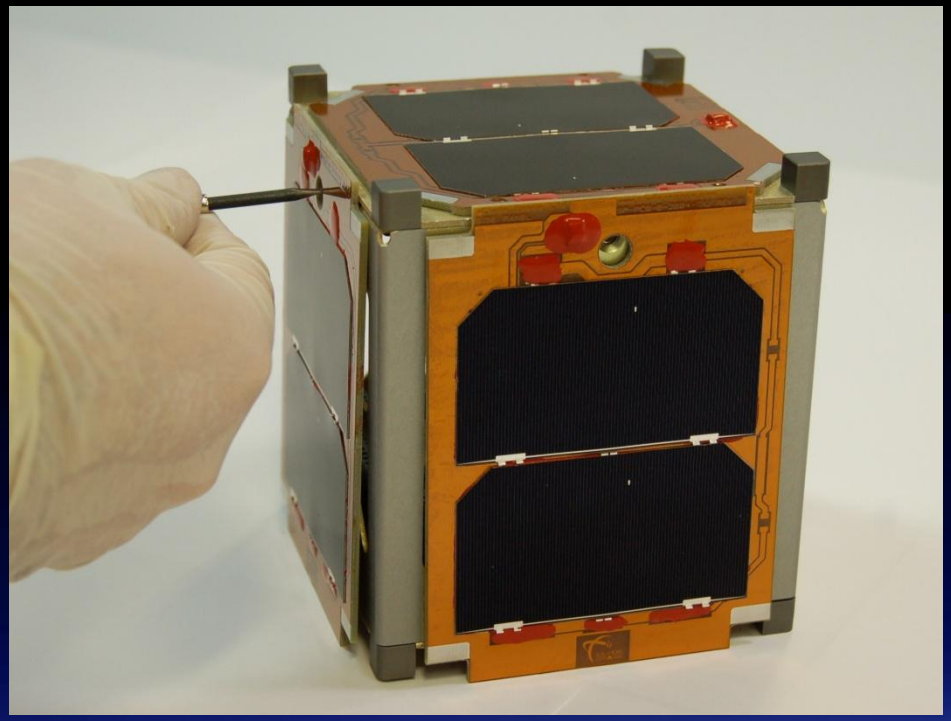
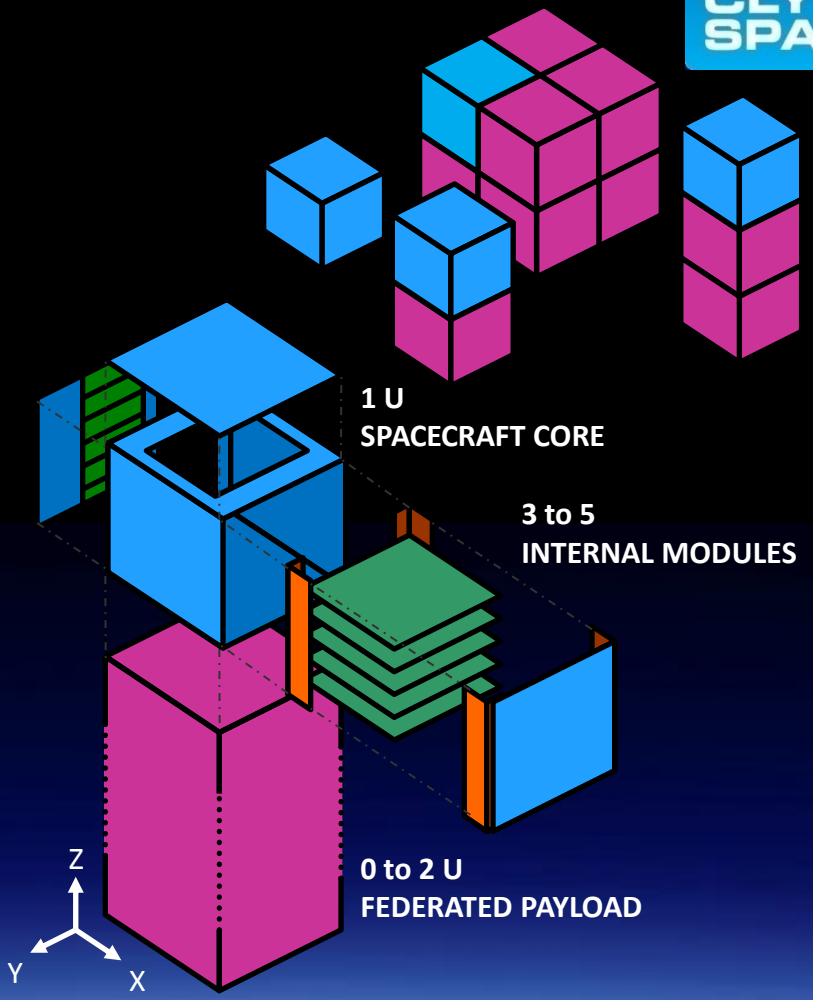
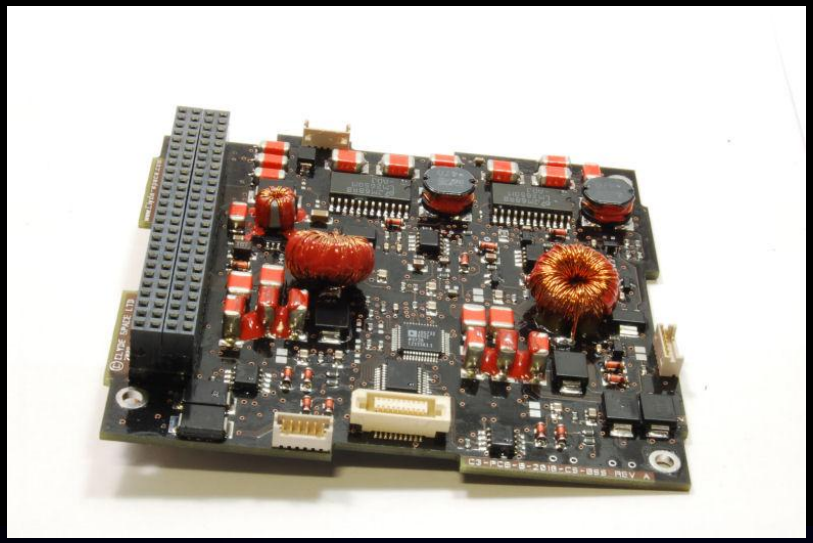
Overview - 1

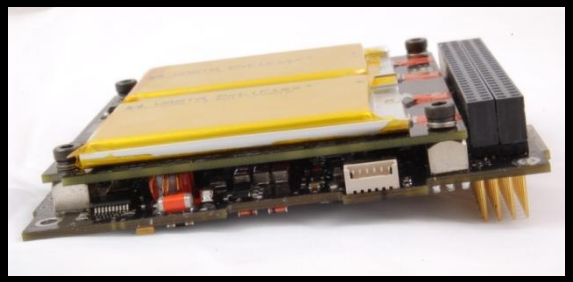
Micro-spacecraft

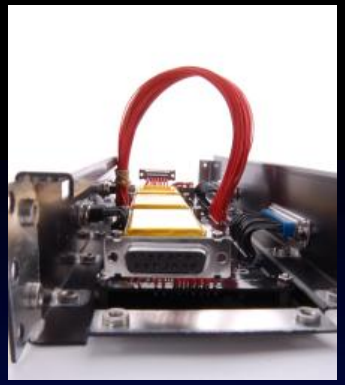




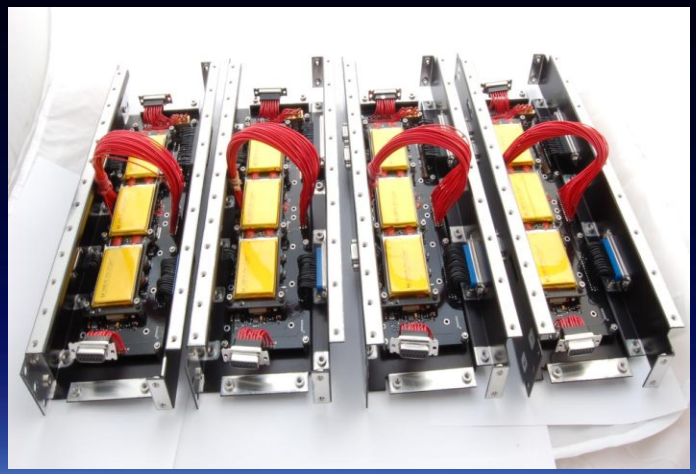
Overview - 2







Lithium Polymer Batteries for Small & Micro-spacecraft



BEV-01

University of Texas at Austin

Partnership between NASA Johnson Space Centre, UT Austin and Texas A&M University. Contains CS EPS, two battery packs, and solar panels.

Four low earth orbit missions to develop and test autonomous rendezvous and docking technologies

PARADIGM is a pico-scale satellite program, that aims to separate and dock two 5-inch cube satellites. The first generation of the satellites will collect GPS data in two orbits about the Earth and downlink them back to their respective ground stations within two months

Launched in August 2009 on the Space Shuttle Endeavour.

HawkSat-1

Hawk Institute of Space Science

Proof of concept vehicle for future satellites

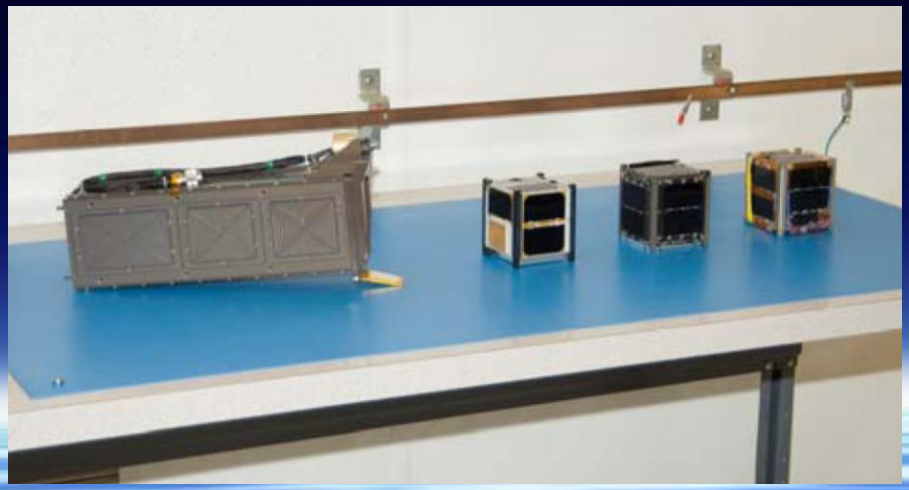
HawkSat-1 subsystems include:

- Command and Data Handling (C&DH),
- Electrical Power System (EPS) with Solar Panels to recharge the flight batteries
- Radio Communications with an Antenna Deployment System.

Carries experiment to expose newly developed materials to radiation and temperature encountered in space

Data relayed to the flight computer every 20 minutes. Flight computer records data for subsequent transmission to the ground stations.

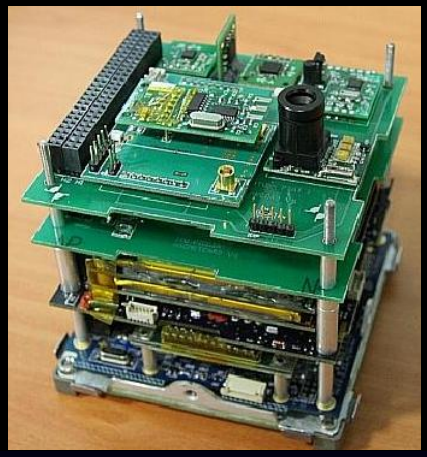
Radio checks for a compatible ground station signal every 20 seconds. Immediately establishes communications link and transmit an identification message followed by the mission data.



ITU-pSAT1

Istanbul Technical University

Taking low resolution pictures from space and communicate with the Ground station in less than 2 years

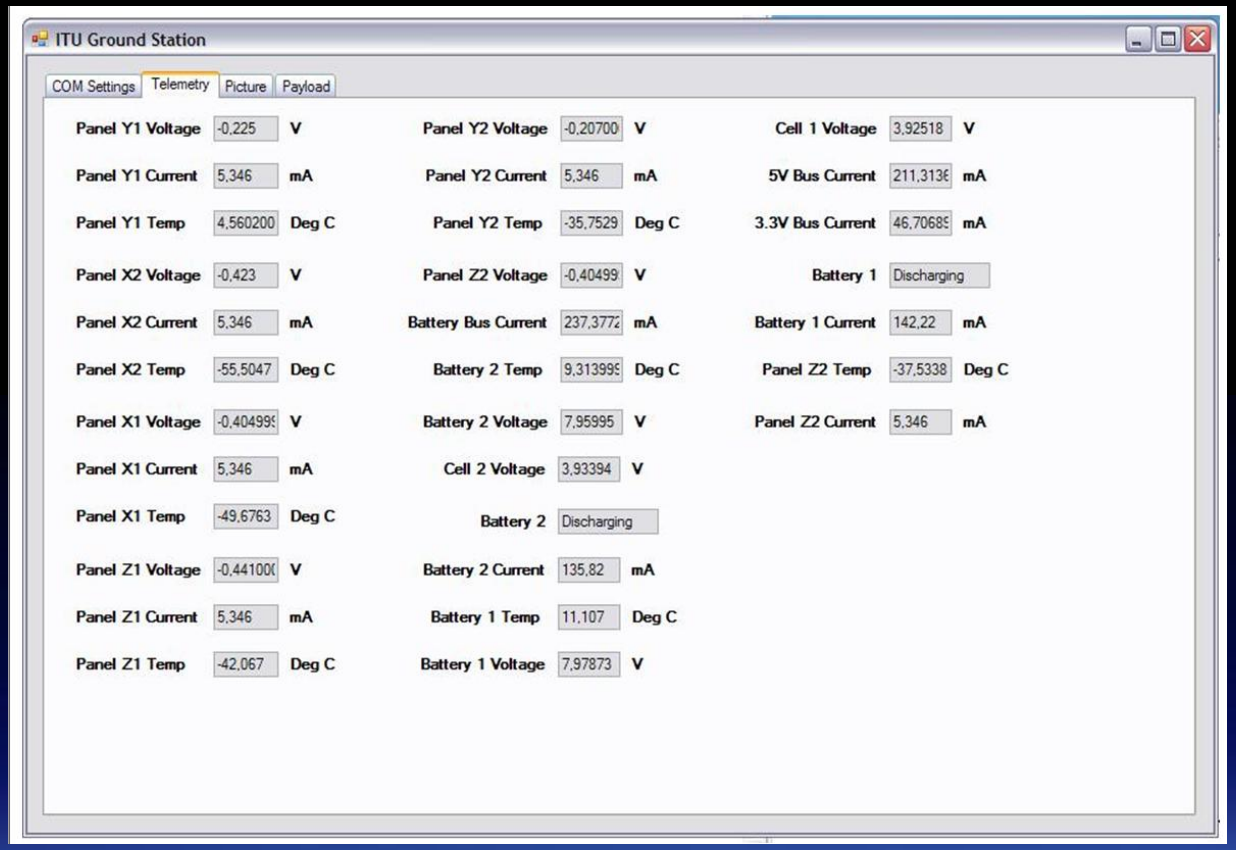


ITU-pSAT1 carries a camera, magnetometer, accelerometers and other payload instruments.

ITU-pSAT1 was launched from India on the PSLV-C14 along with three other CubeSats on September 23, 2009 into LEO.

Telemetry information returned from ITU-pSAT1 in orbit

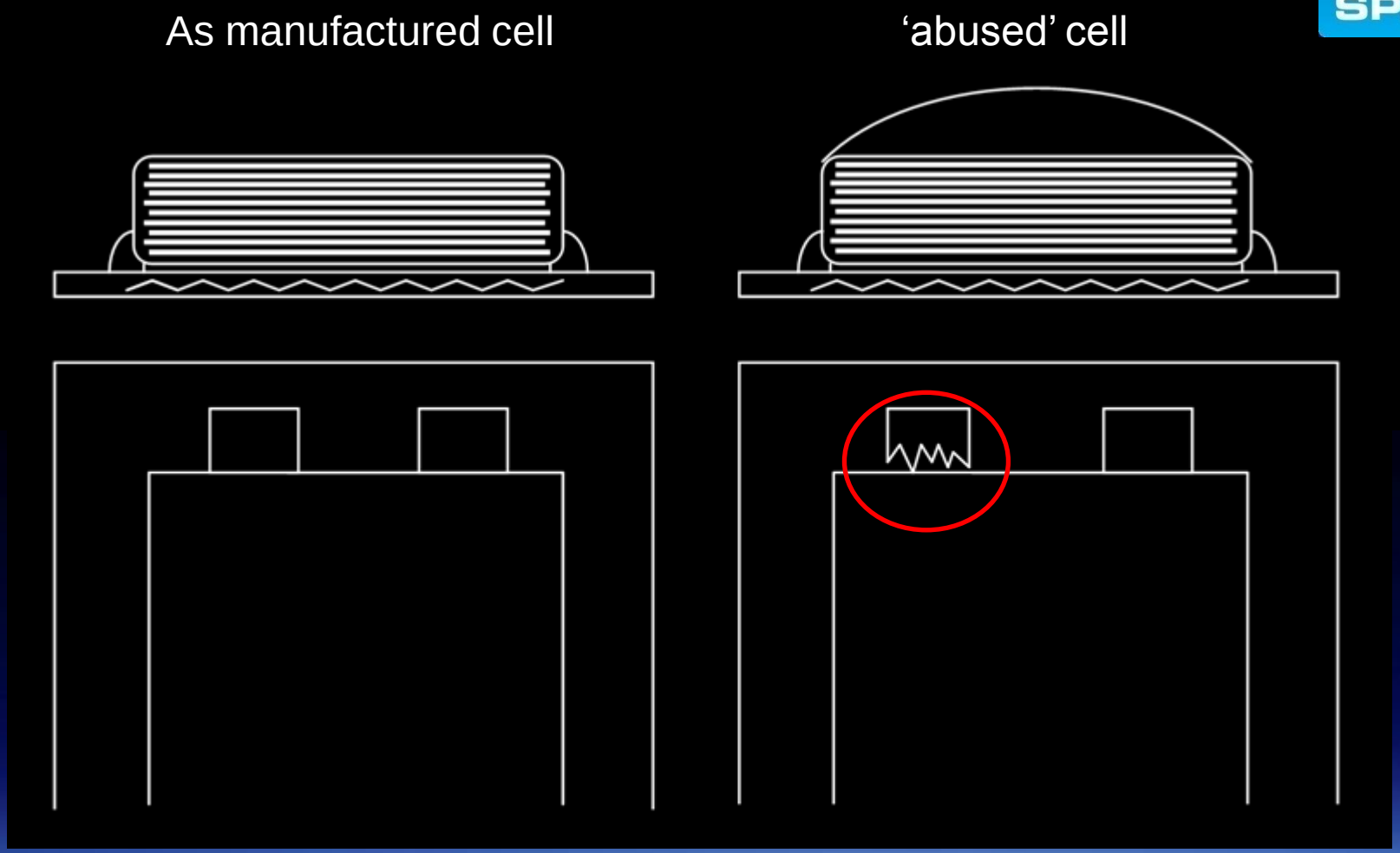
ITU-pSAT1
First Contact Telemetry



Battery Distribution

	University	Commercial/Gvt
1U CubeSat Battery	59	65
3U CubeSat Battery	9	39
‘Remote’ Battery		13
Bespoke Battery		10

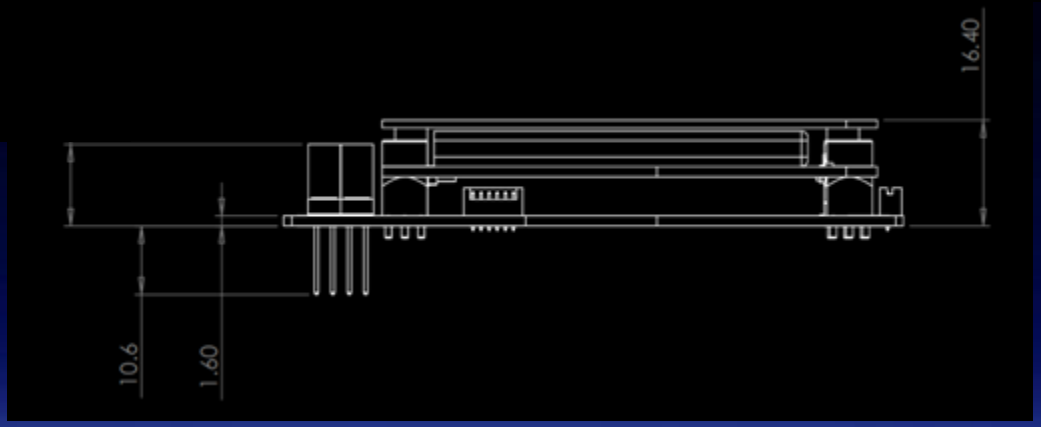
Cell Behaviour in Abuse Conditions



Solution

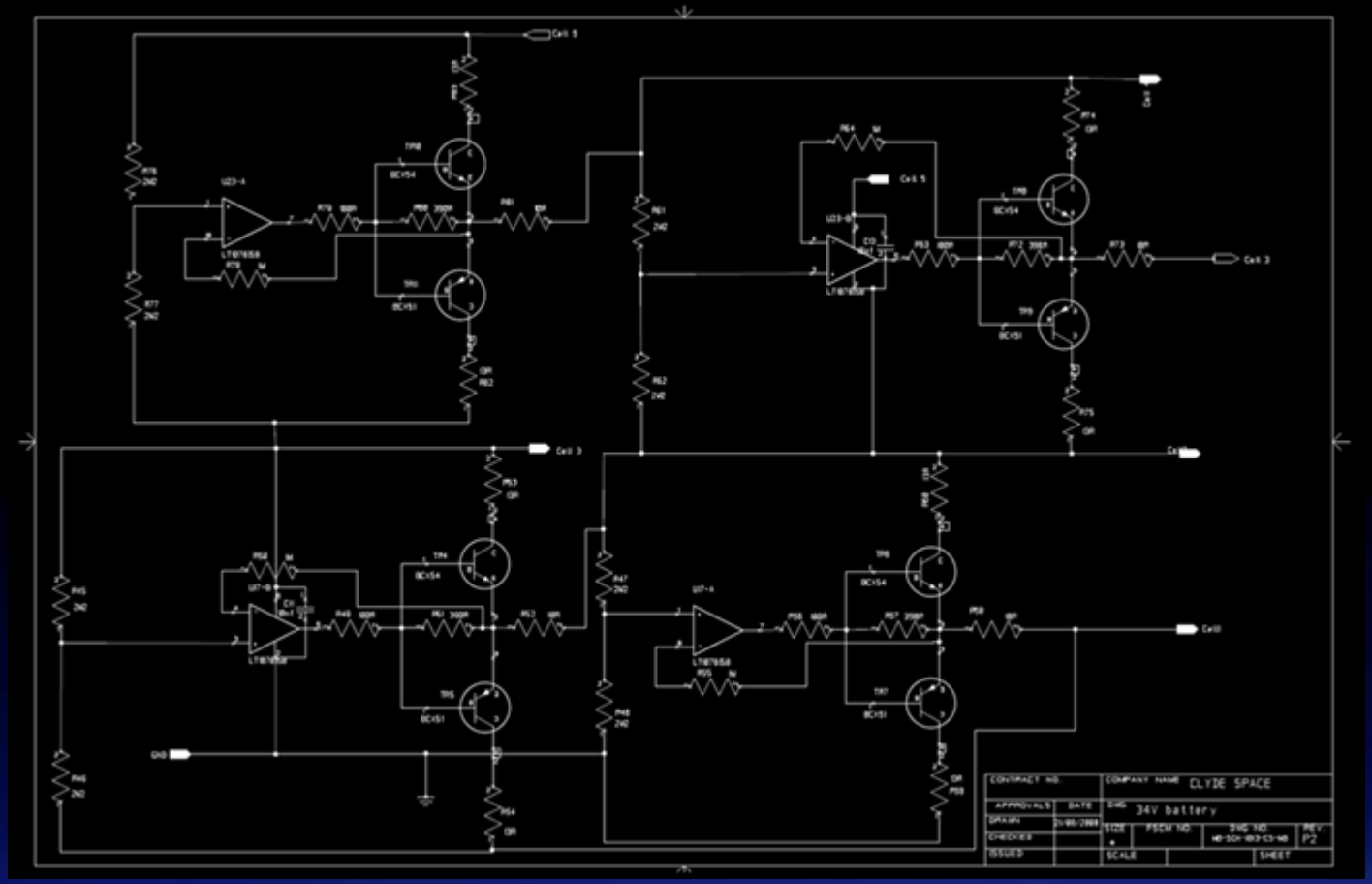
No increase in overall height of stack

Information contained on top panel indicating locations of battery terminals, and other general and safety information on the batteries beneath.



Also, evaluating alternative bonding materials for cells to PCB

Balancing Circuit

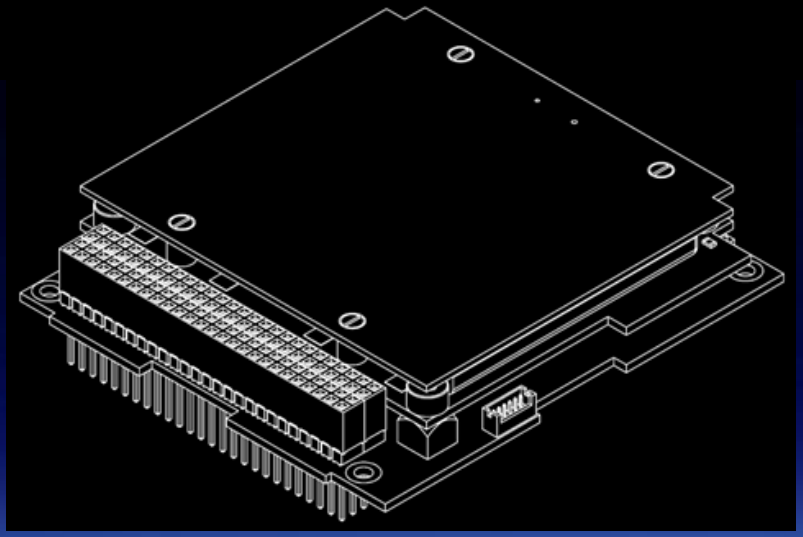


Solution

- Balancing circuit removed for strings of 2 cells (based on test results)
- Evaluating commercially available ICs which perform:
  - Cell Balancing
  - Overvoltage protection
  - Undervoltage protection
  - Overcurrent in discharge
  - Short circuit in discharge conditions
  - Overtemperature protection
  - Cell voltage, charge/discharge current telemetry
  - Thresholds programmable via EEPROM

Conformal Coating

- Conformal coating can clog up in Pumpkin CubeSat header , causing lack of contact.
- Caused by capillary action of liquid coating on pins.



Solution

- Better masking of connector body, and pins
- Use of conformal coating with UV tracer
- Facilitates inspection using UV lamp
- Adequacy of coverage, and ingress of coating into connector
- Microscope inspection after coat also to determine bridging, bubbling, and adequate coverage.

Additional Developments/ Features

- Weight of PCB reduced by adding cutouts below cells
- Developed ‘remote’ battery – able to fit in otherwise unused space inside CubeSat structure.
- Remote battery has its own I2C node
- PTC introduced for over-current protection – replaces active current limiting circuit which drained power from battery
- Telemetry information available via I2C node
  - Battery, and cell voltage
  - Charge/Discharge Current
  - Temperature

Future Work

- Develop new version of small satellite battery
- Life test at ESTEC
- 8 cell strings
- New balancing circuit
- Target energy density for battery including frame, PCB, electronics is 135Wh/kg
- Battery will have its own telemetry node interchangeable with different communication protocols

Conclusion

- Excellent results and experience with Lithium Polymer Cells
- Ideal Technology for Small Satellite Applications
  - Mounting on PCBs
  - Electronics can be positioned right next to cells
  - Vacuum performance
  - No radiation effects
- Constant evaluation of new cells

External Testing

- NASA Johnson Space Centre
  - Safety and Performance Testing of cells and batteries for flight on Endeavour Shuttle
  - Results will be presented here, tomorrow, 10am
- Aerospace Corporation
  - Safety and Performance testing of cells

Thank you…